

# Multifunctional UV (MUV) Coatings and Ce-based Materials



**Matt O'Keefe and Bill Fahrenholtz**  
Missouri S&T  
Rolla, MO



**John DeAntoni**  
Boeing-Phantom Works  
St. Louis, Mo



**Ben Curatolo**  
Light Curable Coatings  
Berea, OH

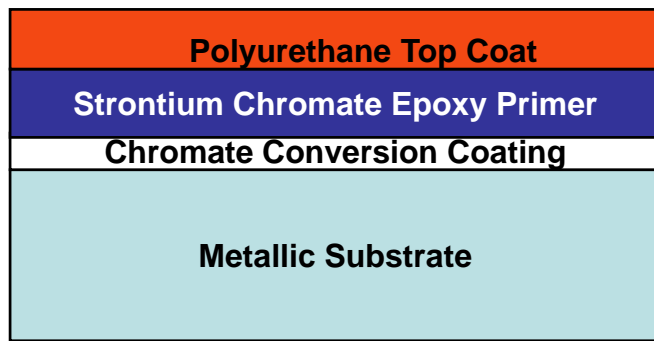


**SERDP Project WP-1519**  
Bruce Sartwell, Chuck Pellerin, Donna Ballard

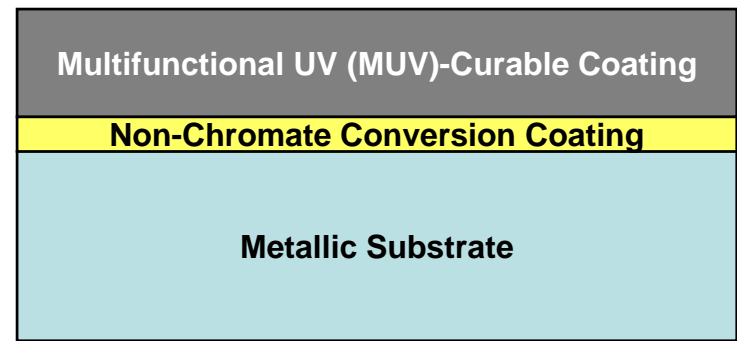
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# Technical Objective

Develop a Two Layer, Chromate-Free,  
Zero TRI/VOC/HAPs Corrosion Coating System  
for DoD Metallic Substrates

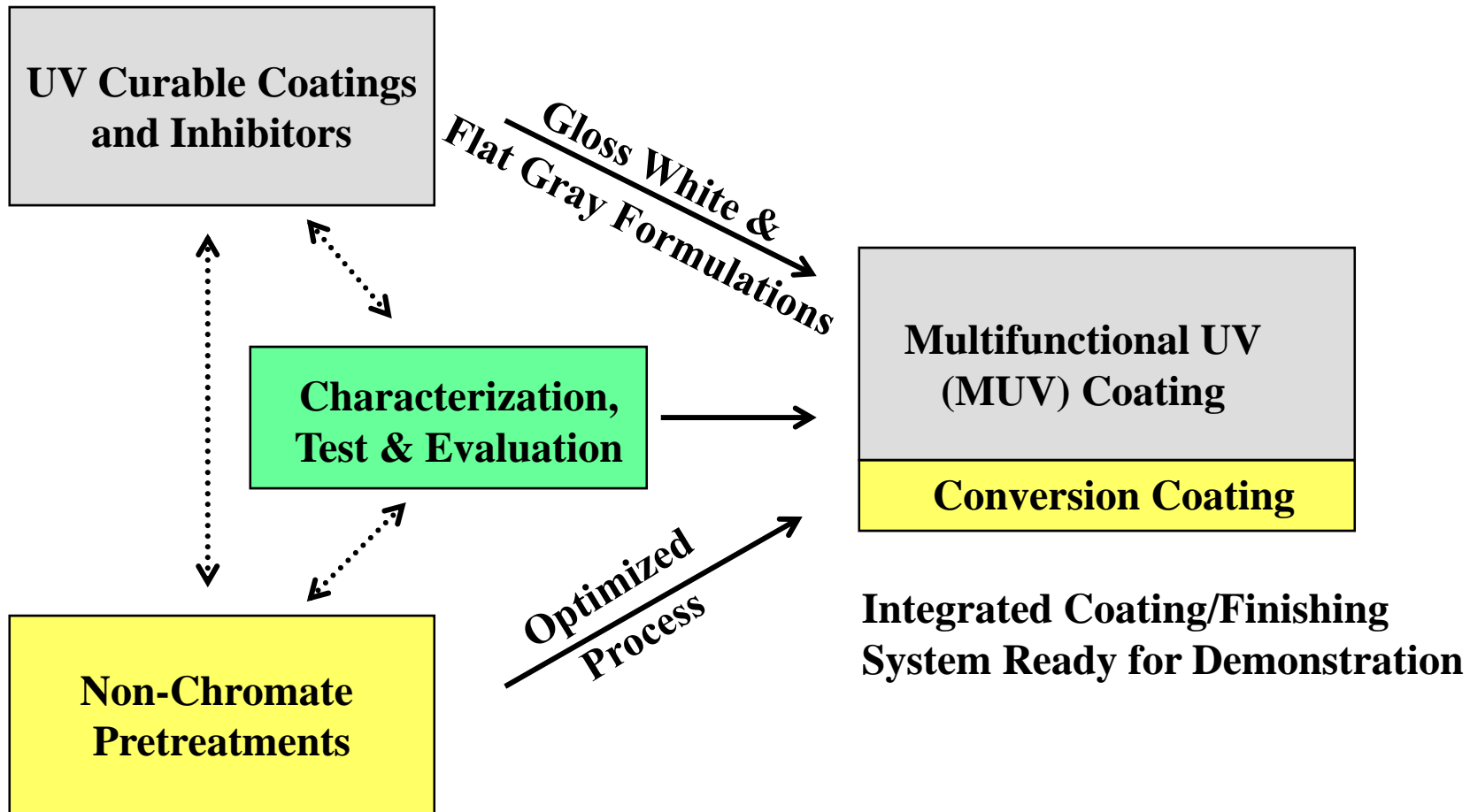


**Current 3 Layer, Cr(VI)  
Based Coating System**

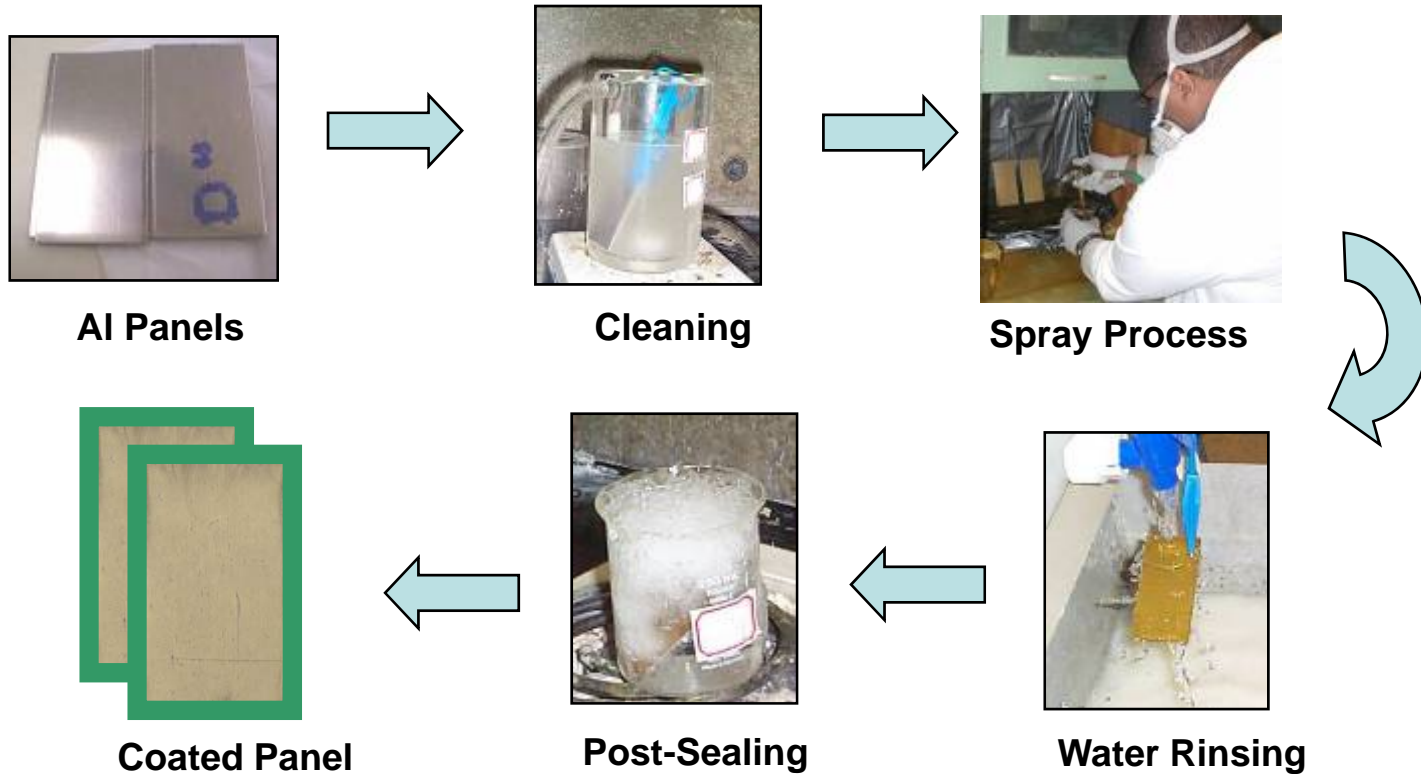


**2 Layer, UV Curable  
Coating System With  
No Cr(VI) and No VOCs**

# Technical Approach

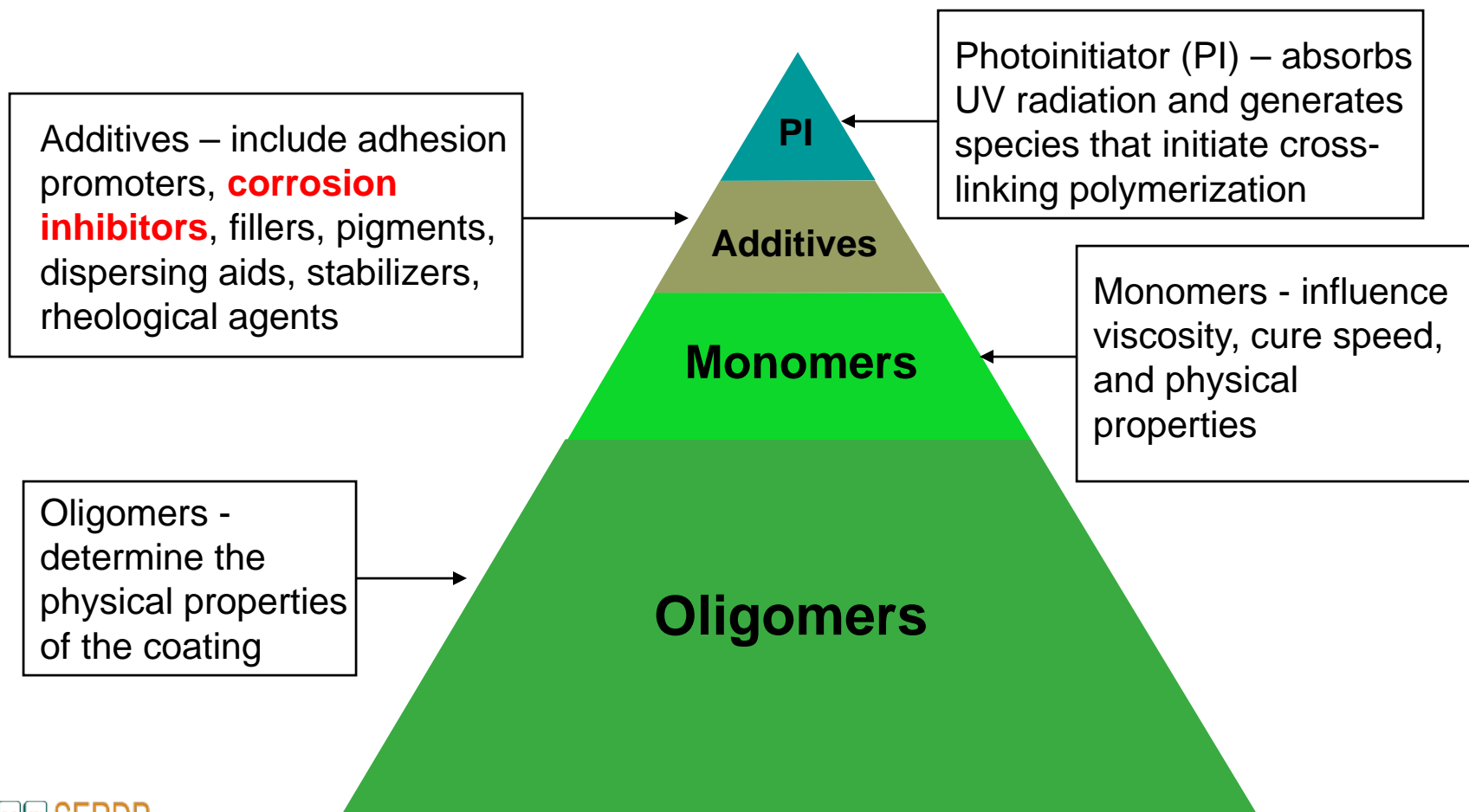


## Cerium Pretreatment Deposition Process Development



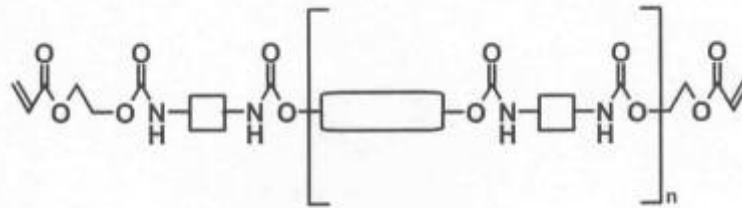
Process Is Environmentally Benign and Developed to Be Compatible with Current Military and OEM Operating Procedures

## Identify Oligomer, Monomer, Photoinitiator and Additive Chemistry of a Multifunctional UV (MUV) Curable System



## Identification Of Oligomer, Monomer, Photoinitiator, and Additive Chemistry For UV Curable Self-Priming Topcoat System

- Evaluate state of the art chrome free corrosion inhibitor technology
- Evaluate Series Of Aliphatic Acrylated Urethane Oligomers That Demonstrate Good Flexibility And Good Weatherability Properties



- Design of Experiments To Optimize Gloss And Other Important Properties Through **Controlled Reaction Rates** Of Monomers
  - Acrylate Groups And Other Reactive Functional Groups
  - Monofunctional And Multifunctional Materials

# Introduction

**Surface Preparation of Al 2024-T3 and Al 7075-T6 for Cerium-based Conversion Coatings (CeCC) Investigated**

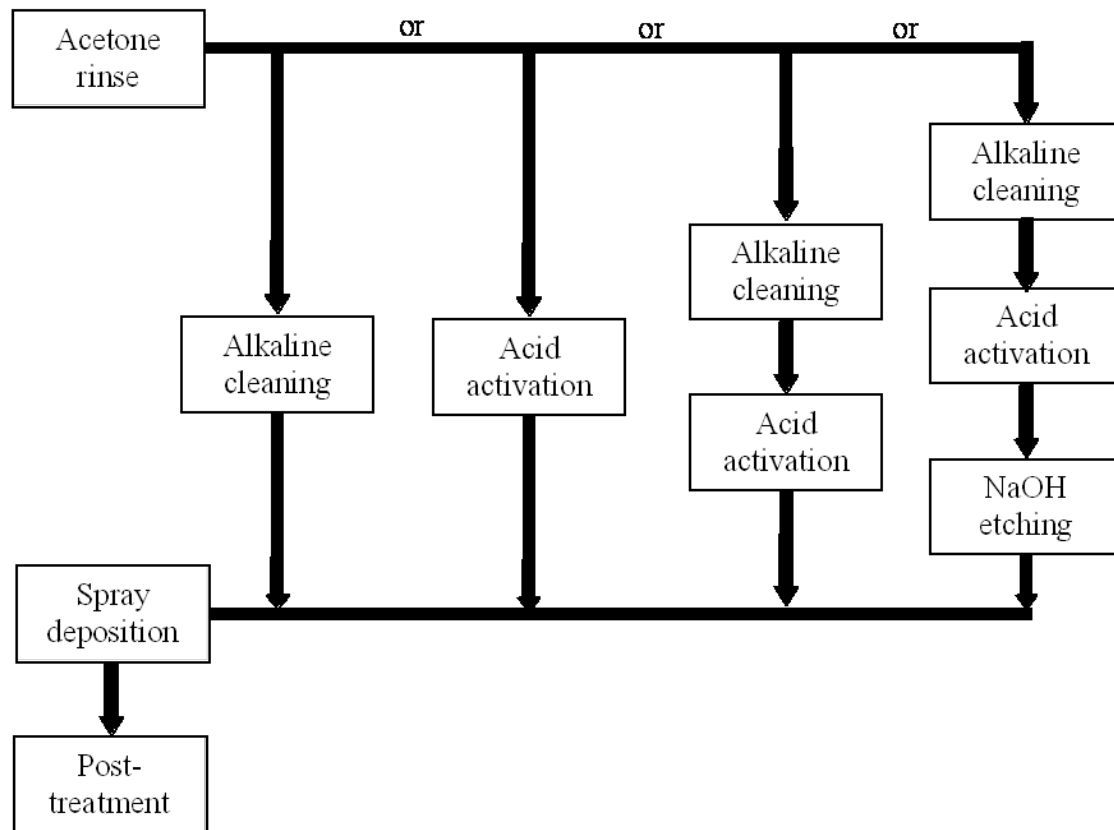
**Multifunctional UV (MUV) Coatings Deposited onto CeCC and CrCC on Al 2024-T3. Two Inhibitors, A & B, Investigated.**

- Non-UV Coatings Used as Controls**
- Inhibitor B was Repeated for Extensive Testing**
- Also Investigated Trivalent Chrome (TCP) and Bare Al 2024-T3**



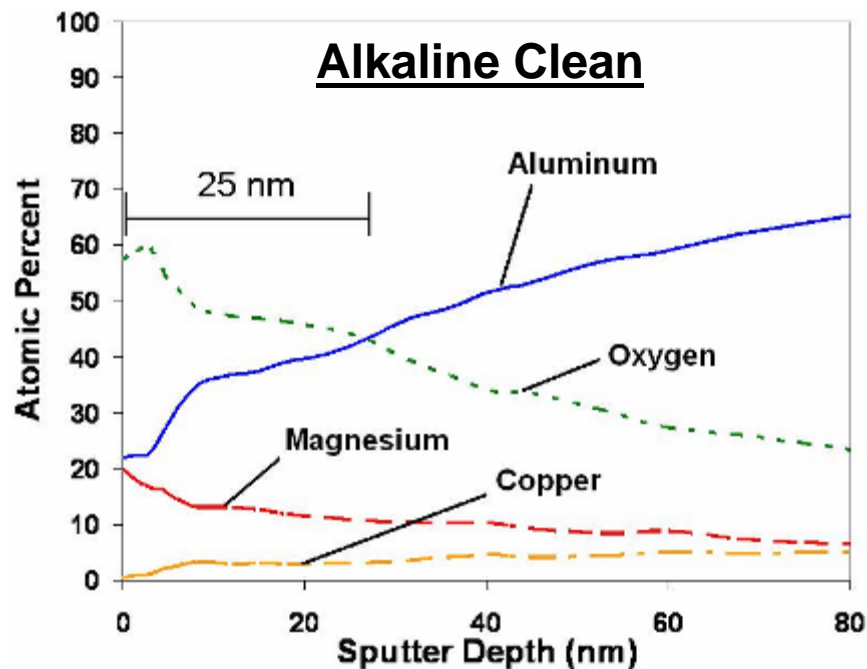
## Critical To Non-Chromate CCs

- Substrates  
AI 2024-T3  
AI 7075-T6
- Desmutting  
Acetone
- Degreasing  
Alkaline cleaning
- Deoxidation  
Acid or Alkaline etching

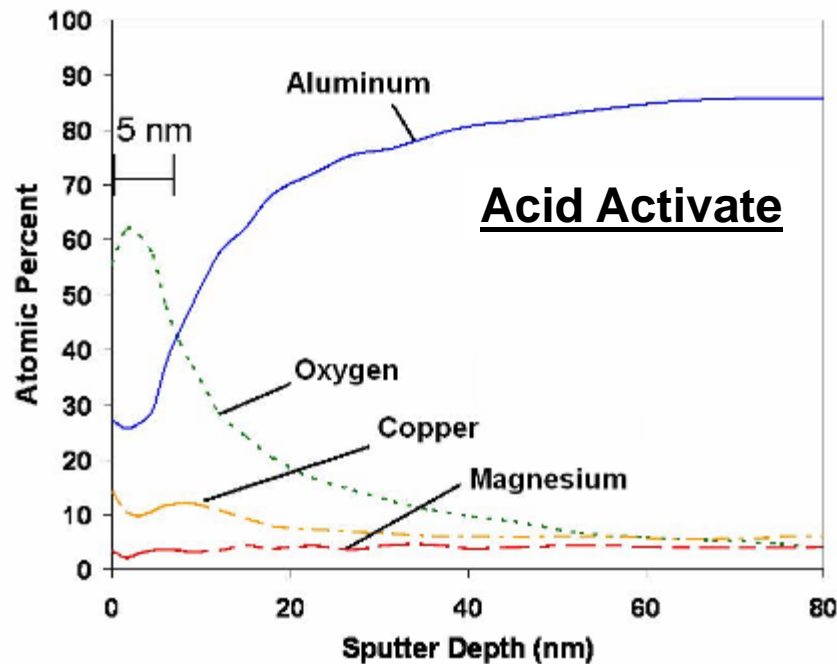


# CeCC Surface Preparation

- Alkaline cleaning (5 wt.%, 55°C)  
Oxide thickness ~25 nm  
Surface rich in Mg and Al



- Acid activation (1 wt.%  $\text{H}_2\text{SO}_4$ , 50°C)  
Oxide thickness ~5 nm  
Surface rich in Cu  
**Exposed IMCs??**



AI 2024-T3

# CeCC Spray Deposition

- Alkaline cleaning  
40 spray-drain cycles required; ~300 nm thick
- Acid activation  
Only 1 spray-drain cycle required; ~200 nm thick

## Alkaline Cleaning

## Acid Activation

6 Sprays

12 Sprays

25 Sprays

40 Sprays

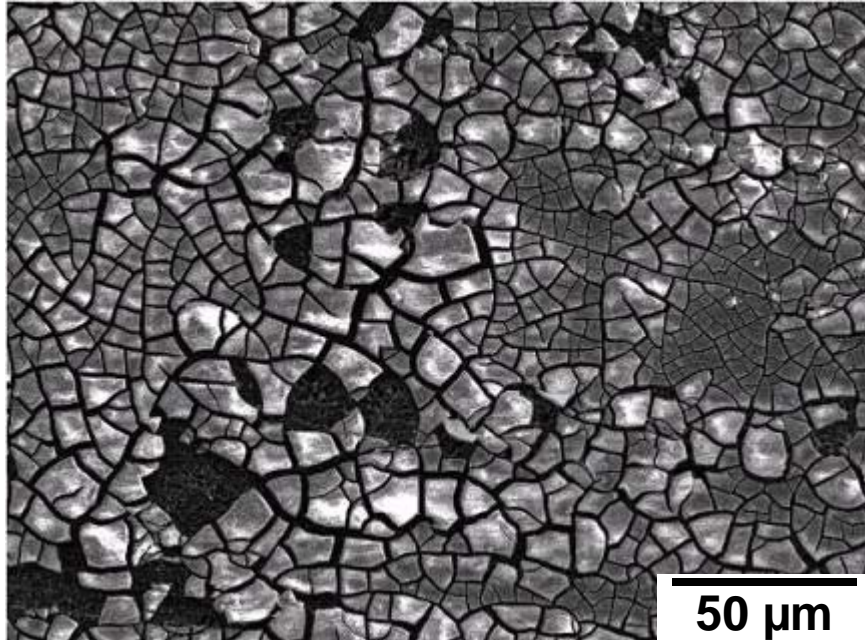
1 Spray



**AI 2024-T3**

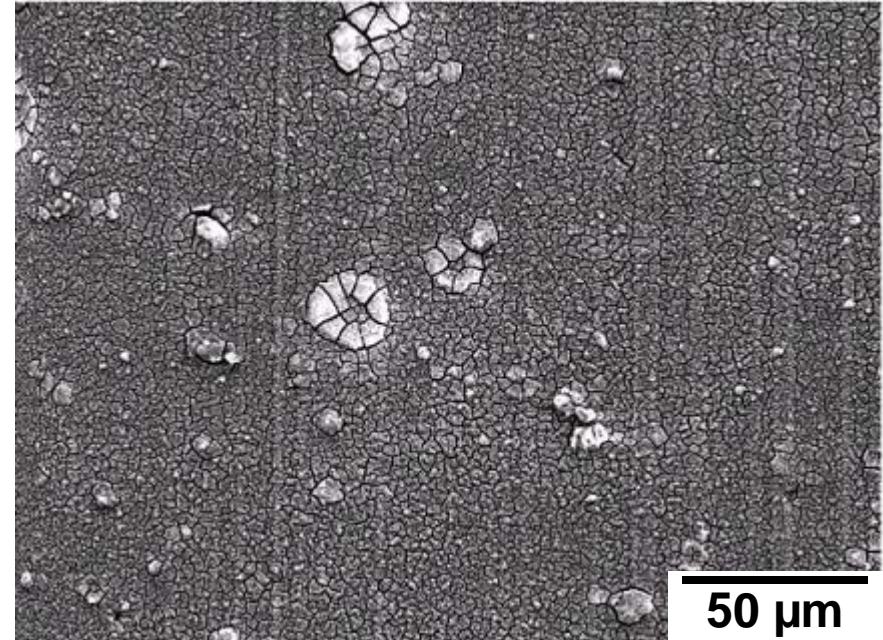
# CeCC Spray Deposition

**Alkaline Clean, 40 Spray-drain cycles**



**Fails After 3 Days ASTM B117**

**Acid Activated, 1 Spray-Drain Cycle**



**Passes 7 Days ASTM B117**

**AI 2024-T3**

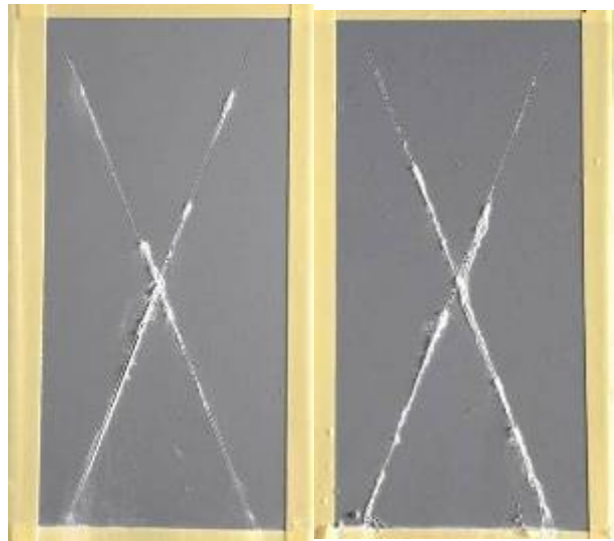


# MUV Coatings

Integrated Coatings -3000 Hour Salt Spray Results Round 1, 2024-T3

Best Performance with UV Cured Inhibitor B

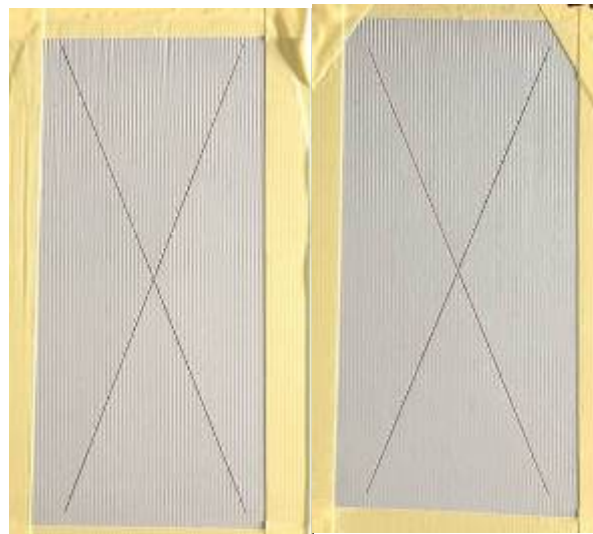
- Inhibitor B Performance Better Than All Others, Including Cr(VI)



**Cr(VI)  
Control**

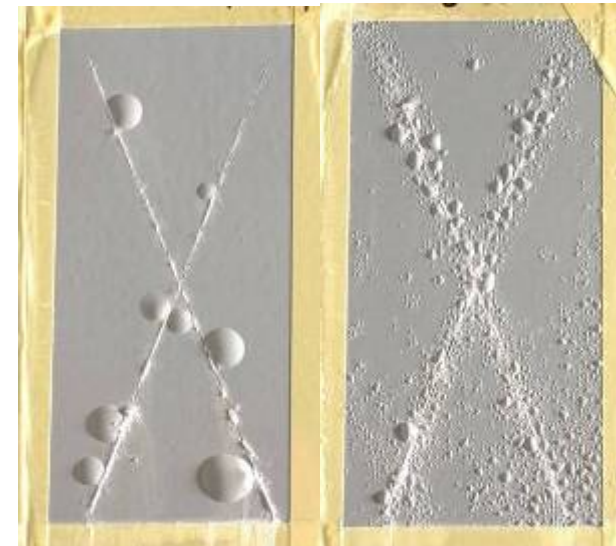
**No Cr(VI)  
Control**

**Non-UV**



**Inhibitor B  
On CrCC**

**Inhibitor B  
On CeCC**



**Inhibitor A  
On CrCC**

**Inhibitor A  
On CeCC**

**UV Cured**

# MUV Coatings

## 1000 Hours Xe Arc Weathering

	Initial 60° gloss	Final 60° gloss	Delta E
Inhibitor B	2.7	1.9	3.1
Inhibitor A	7.1	1.9	7.5
Chrome Control	2.0	1.8	1.6
Chrome free control	1.9	1.7	1.6

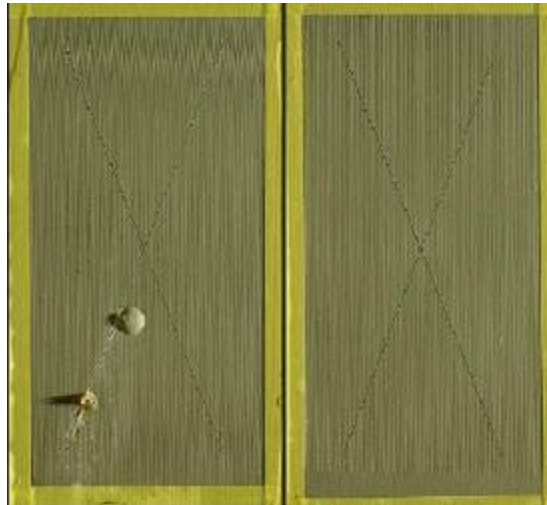


# MUV Coatings

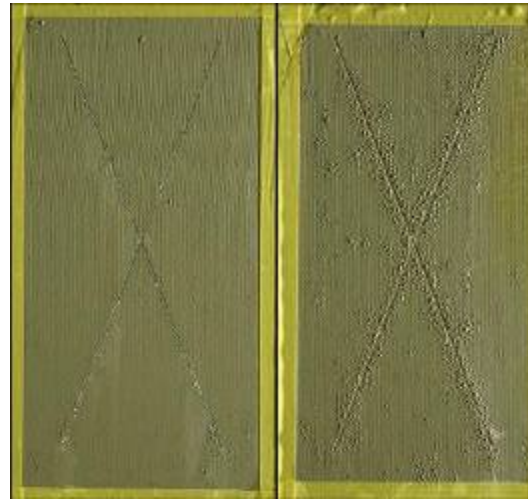
## Reverse Impact Flexibility Testing

Formula	Monomer	Inhibitor	Reverse Impact (in-lbs)
1	A	B	8
2	A	A	2
3	B	B	14
4	B	C	16
5	B	A	2

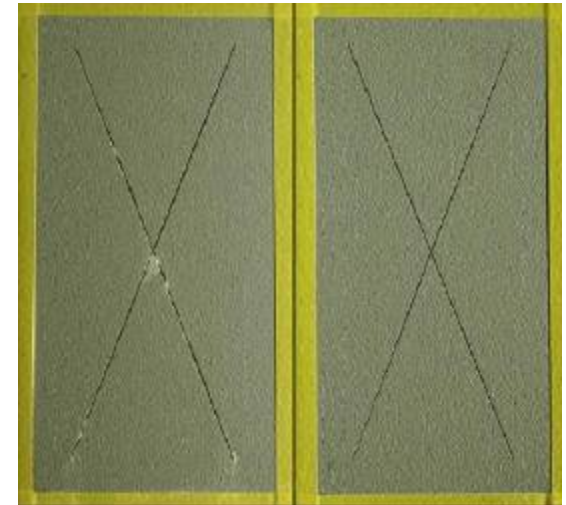
# MUV Coatings



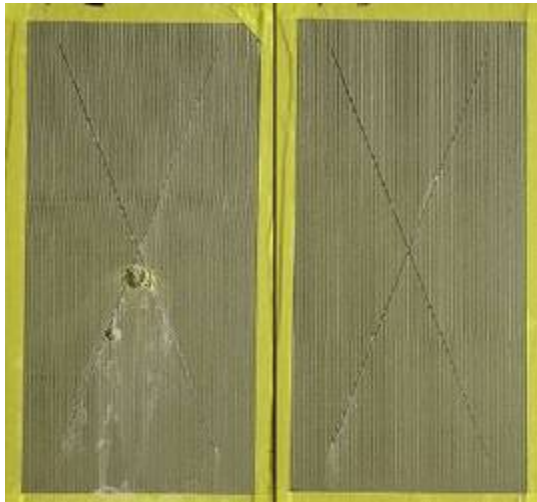
**MUV on CrCC**



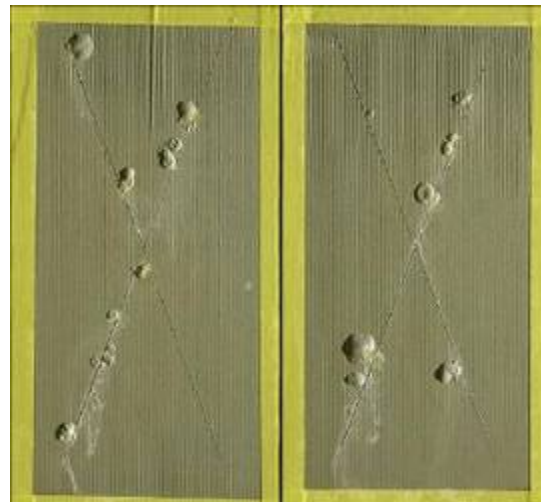
**MUV on CeCC**



**Chrome Control**



**MUV on TCP CC**



**MUV on Bare 2024**

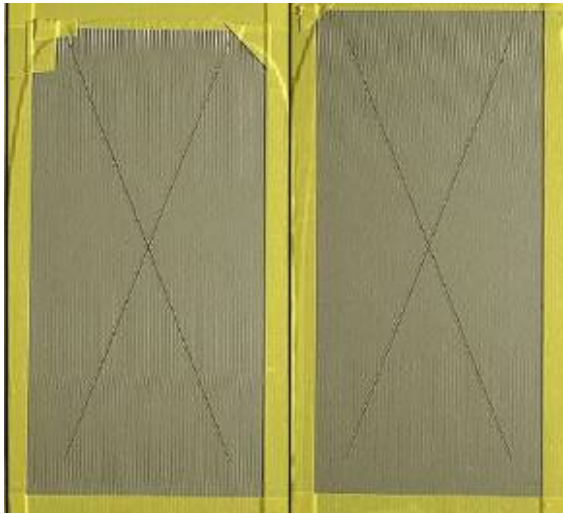


**Chrome free Control**

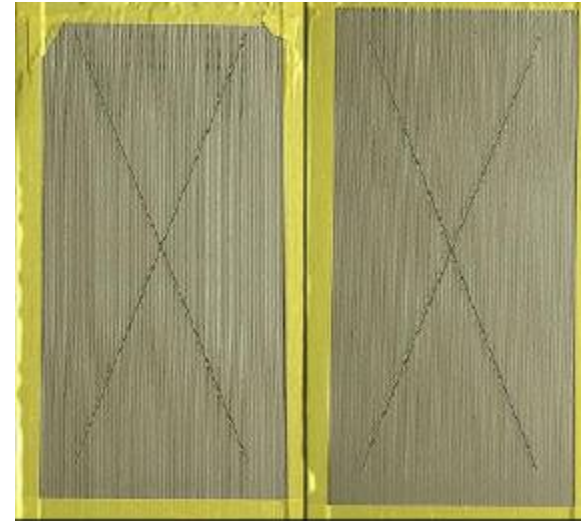
**ASTM B117 – 2000 Hours  
Inhibitor B Round 2**



# MUV Coatings



**MUV on CrCC**

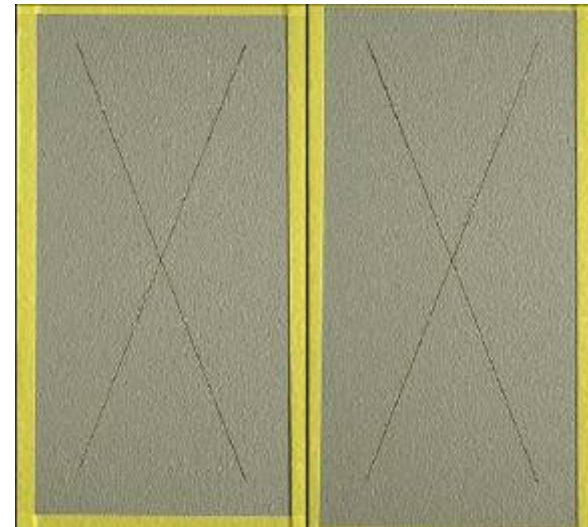


**MUV on CeCC**

**SO<sub>2</sub> Spray After  
500 Hours  
Inhibitor B  
Round 2**

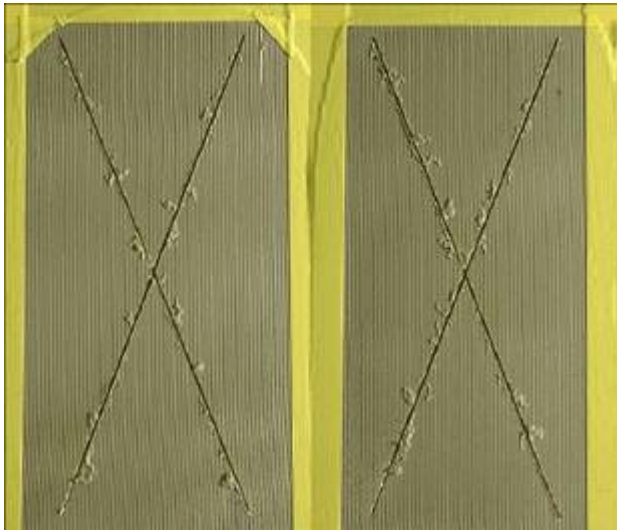


**Chrome Control**

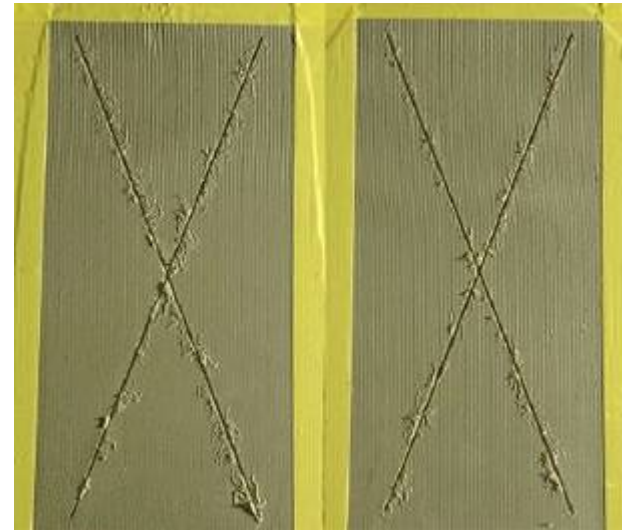


**Chrome free Control**

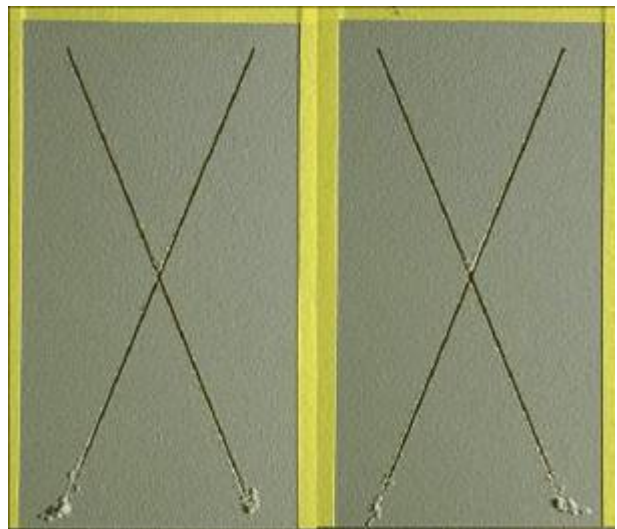
# MUV Coatings



**MUV on CrCC**

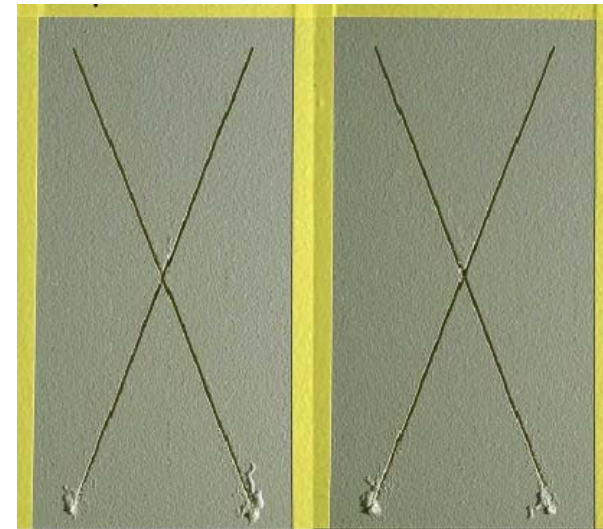


**MUV on CeCC**



**Chrome Control**

**Filiform After  
1000 Hours  
Inhibitor B  
Round 2**



**Chrome free Control**

## **Developing Two Layer, Non-Chromate Corrosion Coating System With UV Curable Self-Priming Topcoat**

- **Spray Deposited Cerium-Based Conversion Coatings**
  - **Surface Preparation Critical**
  - **Influences Deposition and Performance**
- **Multifunctional UV (MUV) Coatings Evaluated**
  - **Capable of Passing ASTM B117 Salt Spray Testing**
  - **Additional Formulation Work to Optimize Properties**